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Overview of High Performance School Design

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GMB Architects-Engineers

GMB Architects • Engineers

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Why?

- ✓Improve Student Performance
- ✓Increase Average Daily Attendance
- ✓Increase Staff Retention
- ✓Reduced Operating Cost
- ✓Reduced Liability
- ✓Reduced Environmental Impact
- ✓Using the School as a Teaching Tool

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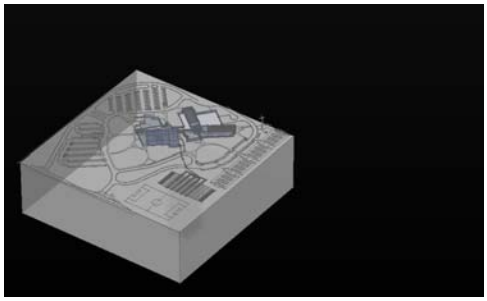
Components of High Performance Design



Site Design

Daylighting & Windows

Building Shell

Lighting/Electrical

HVAC

Renewable Energy

Water Conservation

Recycling

Transportation

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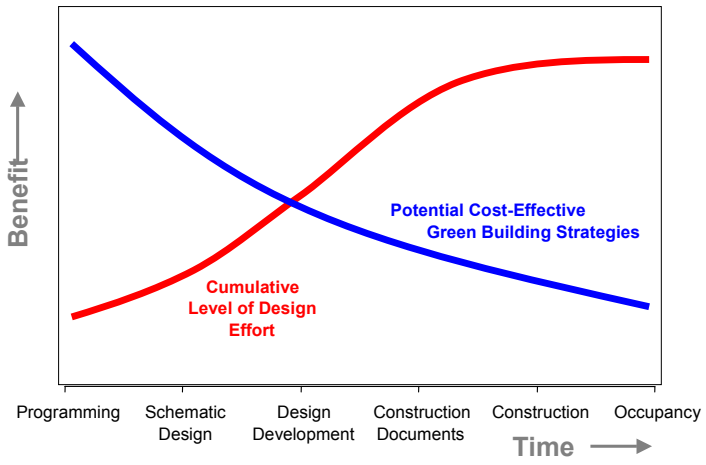
Integrated Building Design Process



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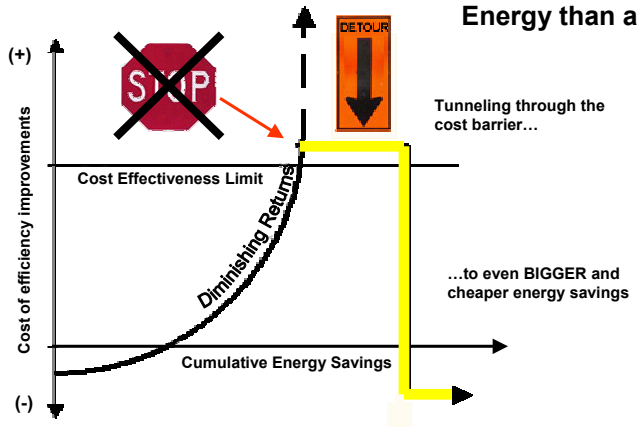
Integrated Design

Using Integrated Design it Often Costs Less to Save a lot of Energy than a little Energy



e.g. envelope, window, light shelves etc. impact system requirements

"Tunneling through the Cost Barrier" ***A. Lovins, Rocky Mountain Institute***

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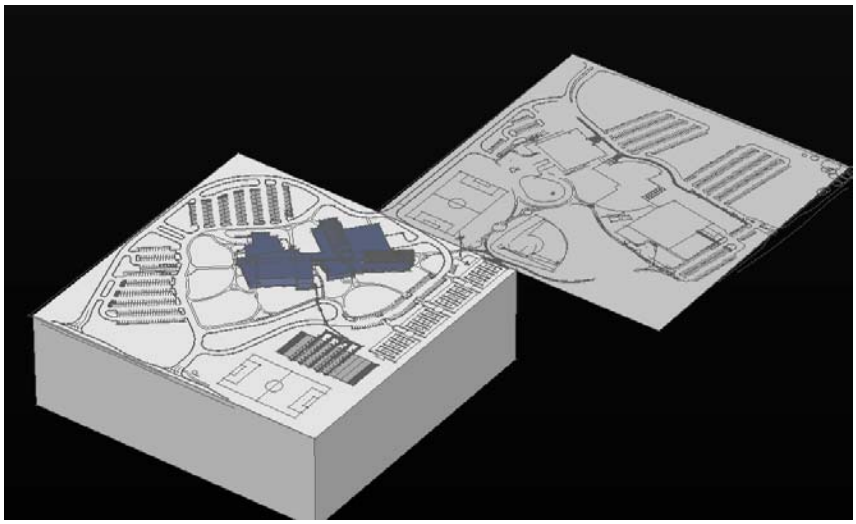
Case Study



Design Guideline: 3 Step Process

1. Reduce the HVAC loads.
2. Reduce the HVAC loads.
3. Reduce the HVAC loads.

High Performance Building Shell

- Building simulation to optimize components
  - Wall insulation
  - Roof insulation
  - Windows

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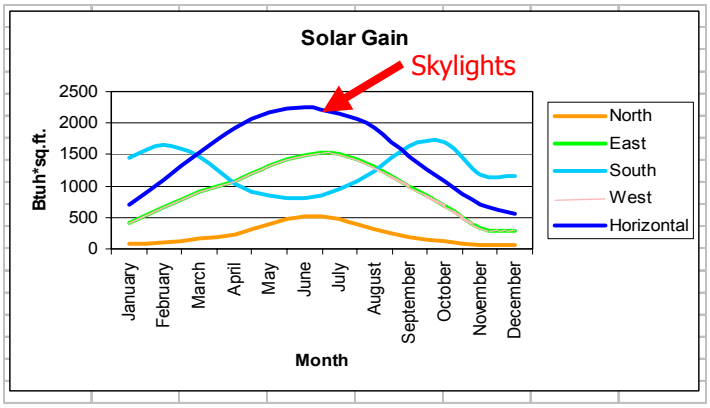
Building Siting/Orientation

- Long Axis of Building Runs East/West
- Reduces Solar Load
- Provides Greater Opportunity for Daylighting



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Windows

- Typically the largest envelope contributor to heating and cooling loads.
- Can provide excellent payback in certain applications.
- Don't' forget to adjust for the frame!
- Example: Typical Low E Double Pane has a "Center of Glass" U Value of 0.32
- If you adjust for a thermally broken aluminum frame, operable window this U Value is actually 0.49 (53% more heat loss!)

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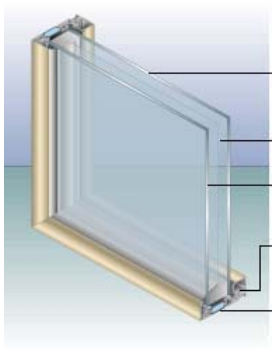
High Performance Glass

- **Thin film glazings (suspended optically clear film between glass)**
- **Overall U Values (including frame) of 0.14 to 0.37.**
- **Shade Coefficients of 0.15 to 0.65.**
- **Be careful with triple pane glass**



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High Performance Glass

- **Can eliminate the need for perimeter heating.**
- **"Rule of thumb": calculate U Value needed to keep interior surface temperature above 60° F at Design Conditions. Example; for OA = 0 °, U= 0.2**
- **Example: typical building with good insulation and 30% glass. Change from Low E double pane to Suspended Film 3 Element (U=0.22):**
  - *Glass cooling load cut by 50%!*
  - *Overall cooling load cut by 15%!*
  - *Glass heating load cut by 62%!*
  - *Overall heating load by 20%!*

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Energy Star Roof at Zeeland

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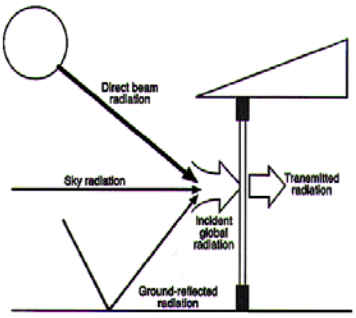
Electrical System

- High Efficiency Lighting Systems
- Daylight Harvesting
- High Efficiency Transformers
- High Efficiency Motors
- Renewable Energy Systems

Daylighting

- Up to 40% of Building Electrical Use is Related to Lighting
- Window Orientation (North or South Facing)



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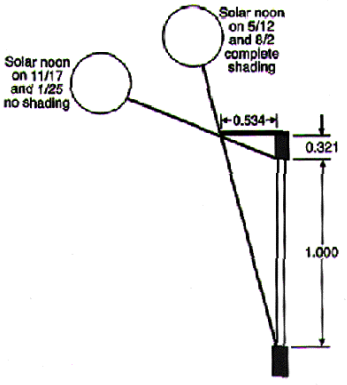
Daylighting

- Overhangs/Light Shelves
  - Prevent Direct Sunlight (esp. in summer)
  - Bounce Light for Additional Penetration
- Window Placement
- Tinting
- Lighting Control



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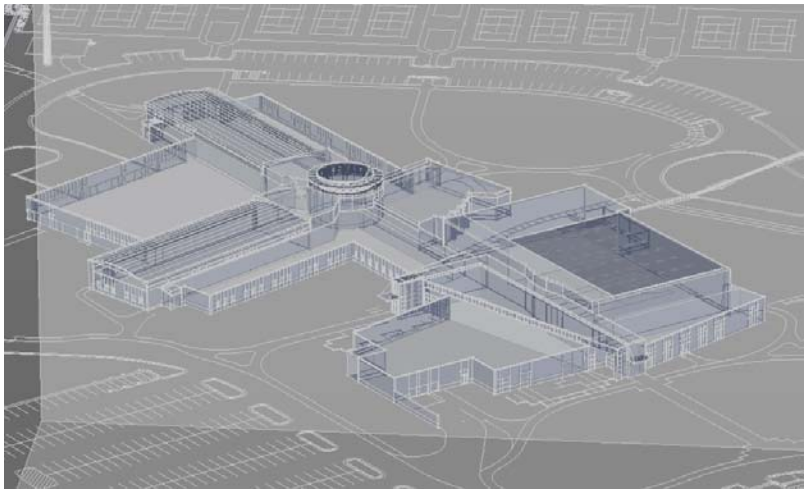
Gym Lighting Design



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Gym Lighting Design

Typical High School Gymnasium

Typical Metal Halide

2.2 Watts/SF

T5 HO Fixture

1.3 Watts/SF

Improved lighting at a power density reduction of 41%!

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Gym Lighting Design

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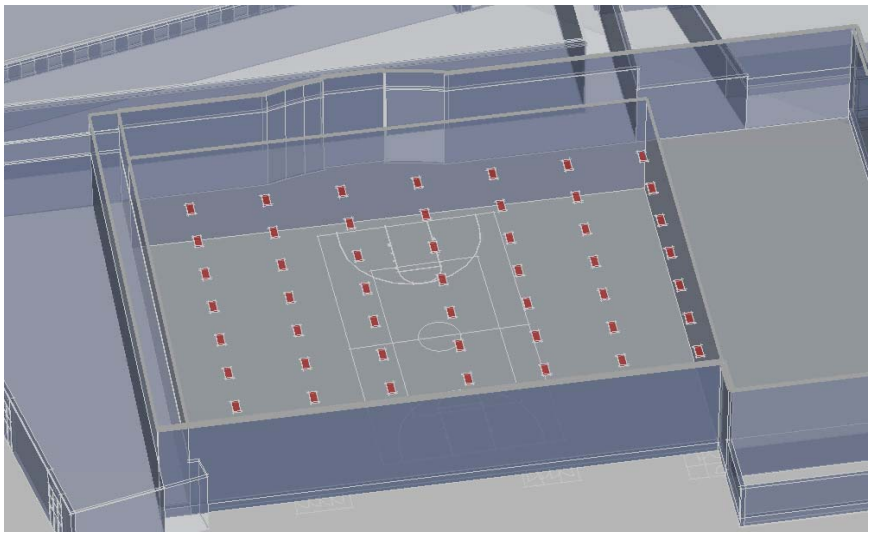
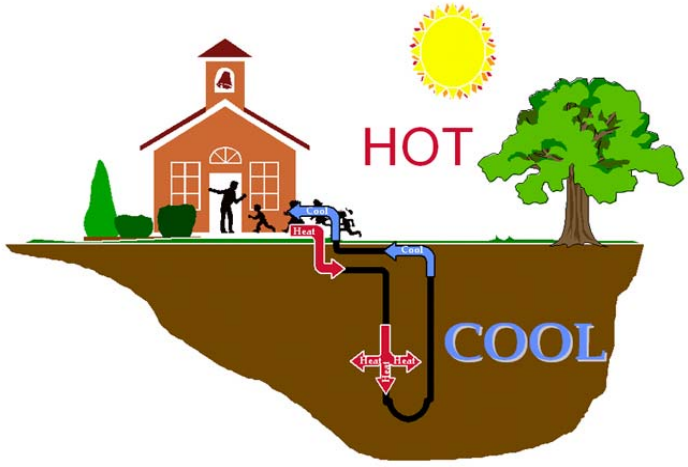
GeoExchange Systems



GeoExchange Systems



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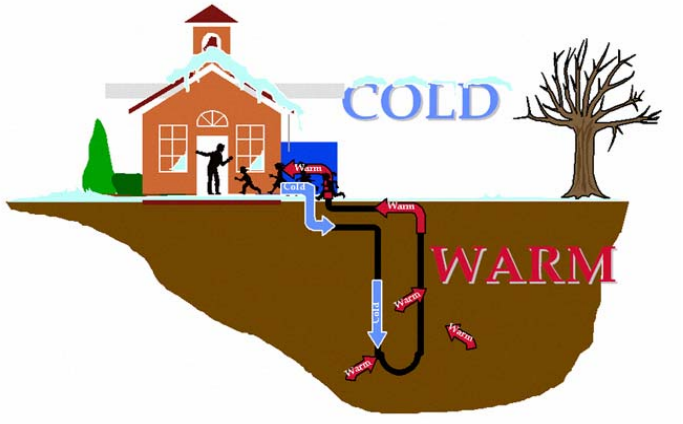
GeoExchange Systems



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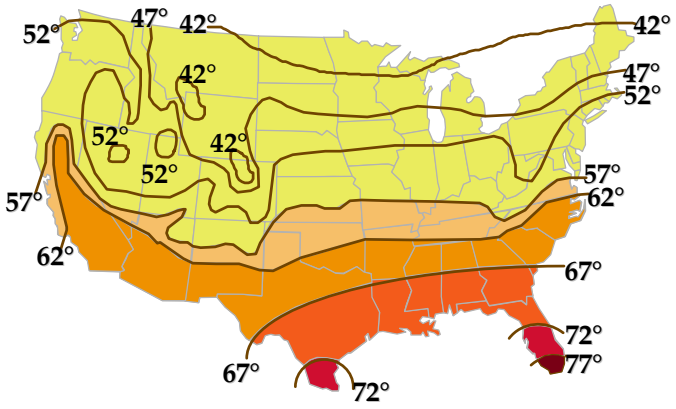
Ground Water Temperatures in Wells 30 to 60 Feet Deep



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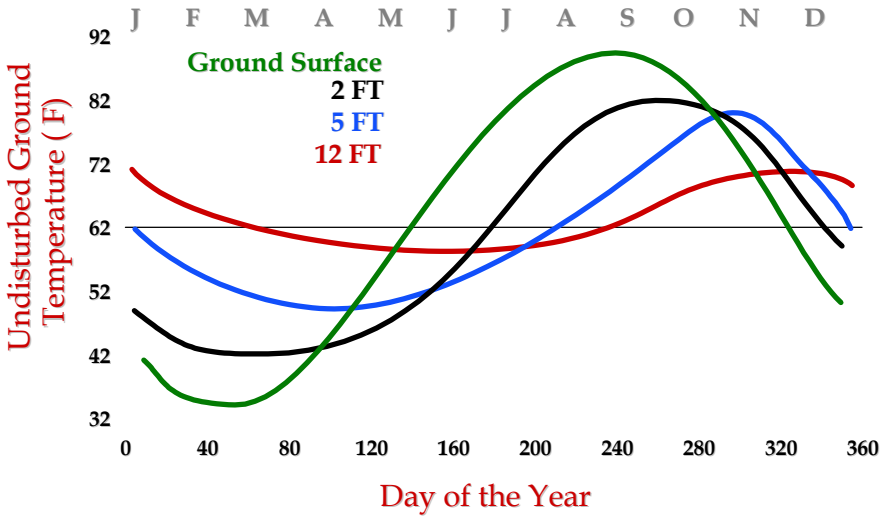
Ground Temperature



Typical Loop

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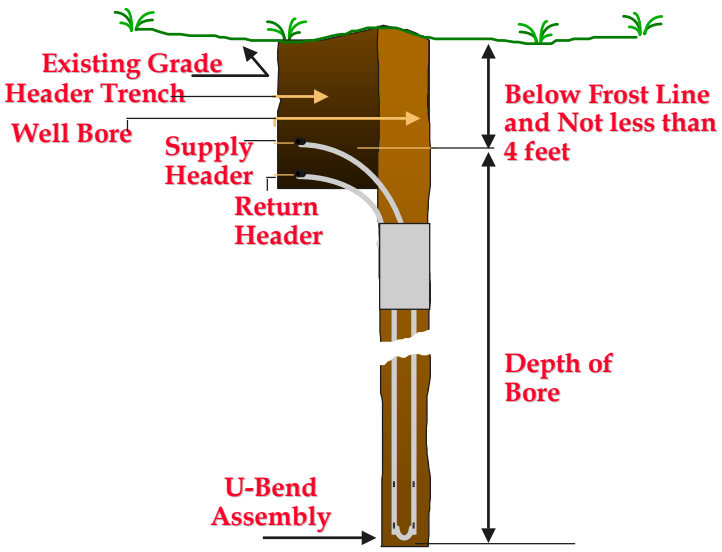
Drilling & Grouting Operation



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Heat Exchanger Installation

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Typical Trench

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Pre-manufactured HDPE Vault

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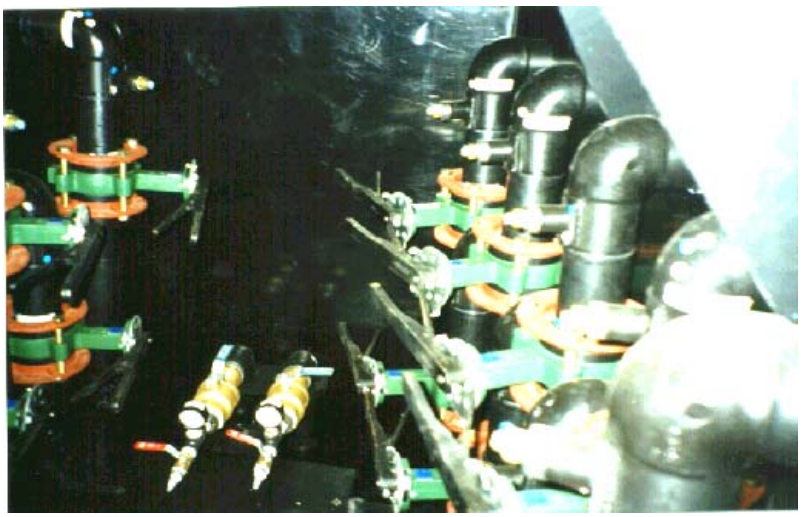

The "Boiler" Room

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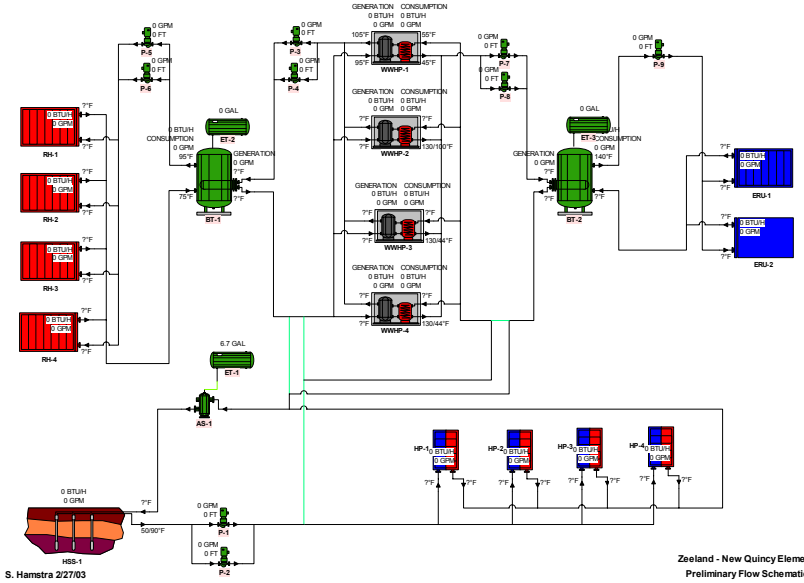
HVAC Innovations



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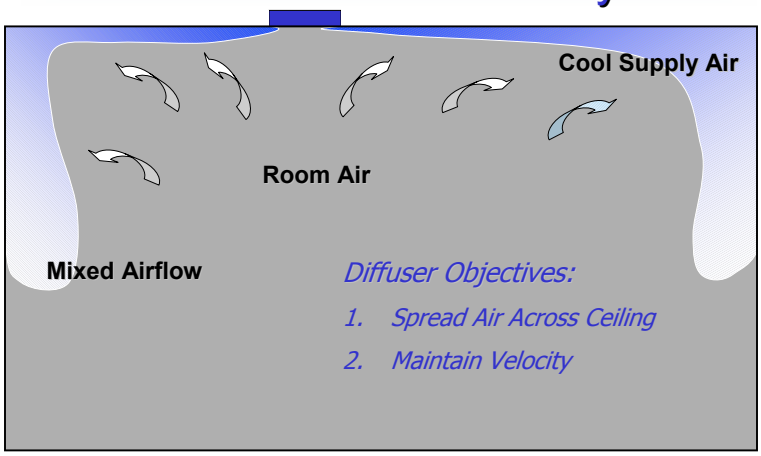
Mixed Systems



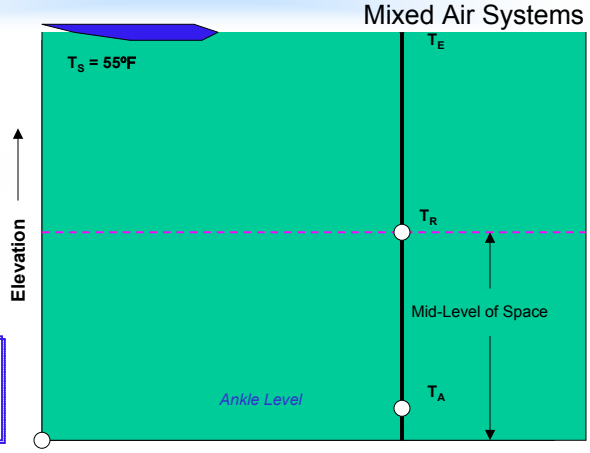
Airflow Requirements

Mixed Air Systems

With Complete Mixing

- $T_E = T_R = T_A$
- $T_R - T_S = T_E - T_S$

$$CFM = \frac{1.1 \times TSHG}{(T_E - T_S)}$$



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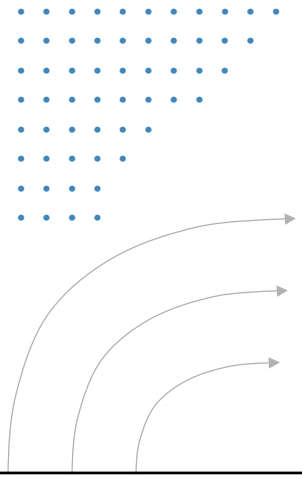
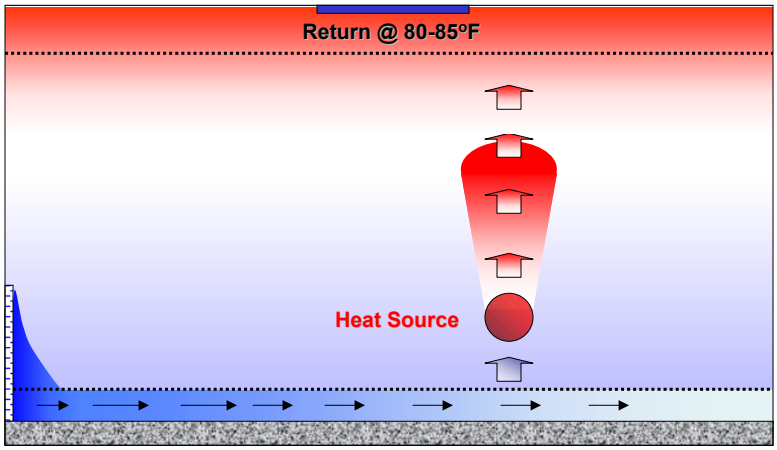


Displacement Air Conditioning

Fundamentals of Displacement



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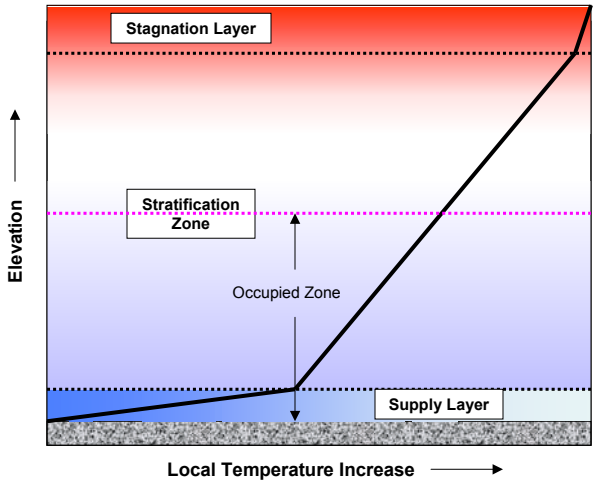
Vertical Stratification



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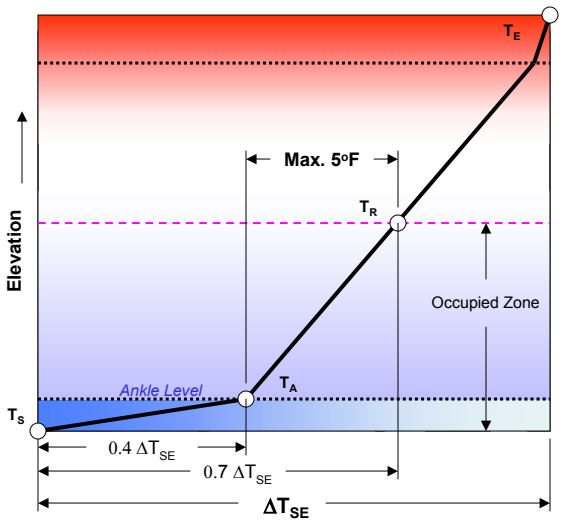
Design Fundamentals

For a Typical Classroom

- ΔT between supply point and ankle level is 40% of the supply/ exhaust temperature difference.
- ΔT between supply and the mid-level room air is 70% of supply/exhaust temperature differential.
- ΔT between occupant ankle and head level (30% of ΔT_{SE} should not exceed 5°F!)



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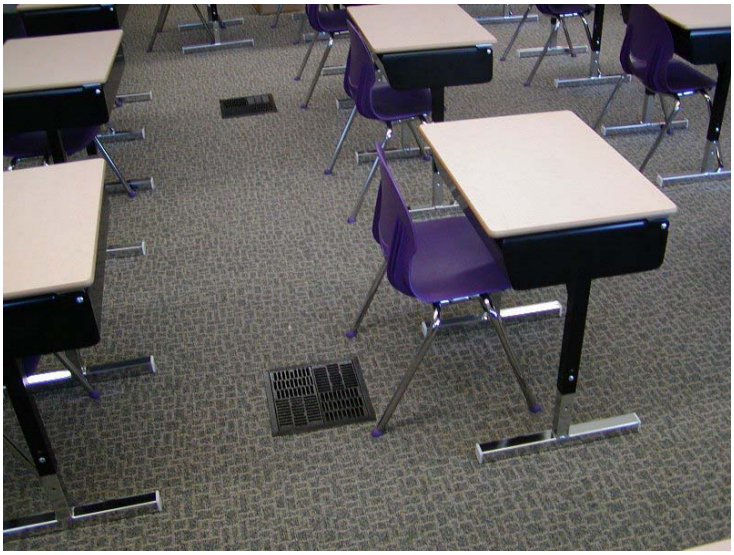

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Displacement with Induction

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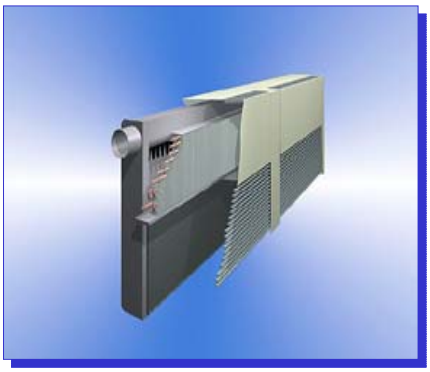
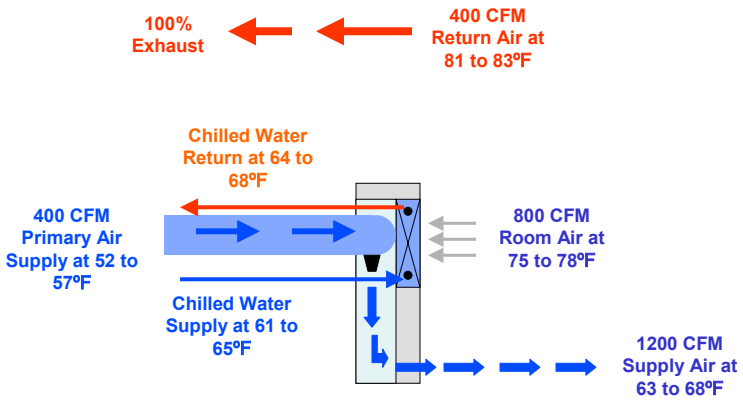
Displacement with Induction

- Induction Nozzles
  - Enables delivery of 52-55F primary air.
  - Induces 2 CFM room air per CFM primary air.
- Integral Heat Transfer Coil
  - Supplements sensible cooling.
  - Eliminates need for separate heating system.



Cooling Operation



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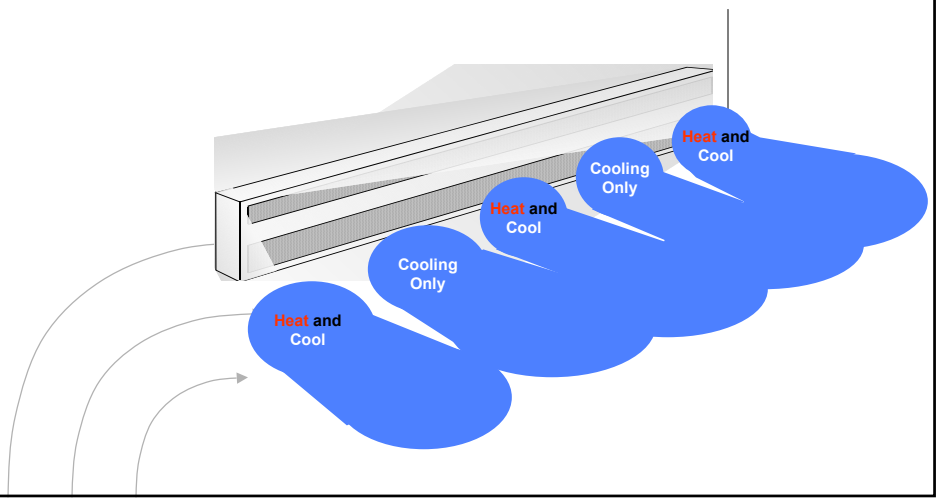
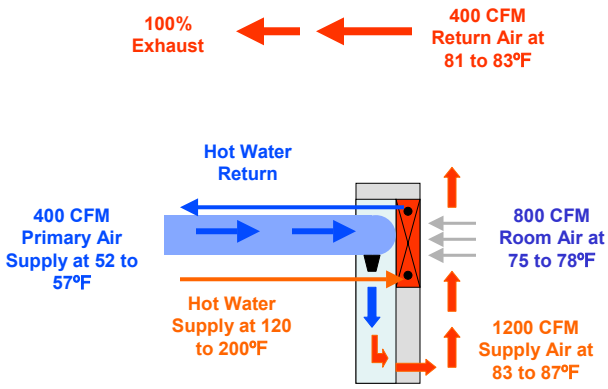
Classroom Cooling Operation



Heating Operation



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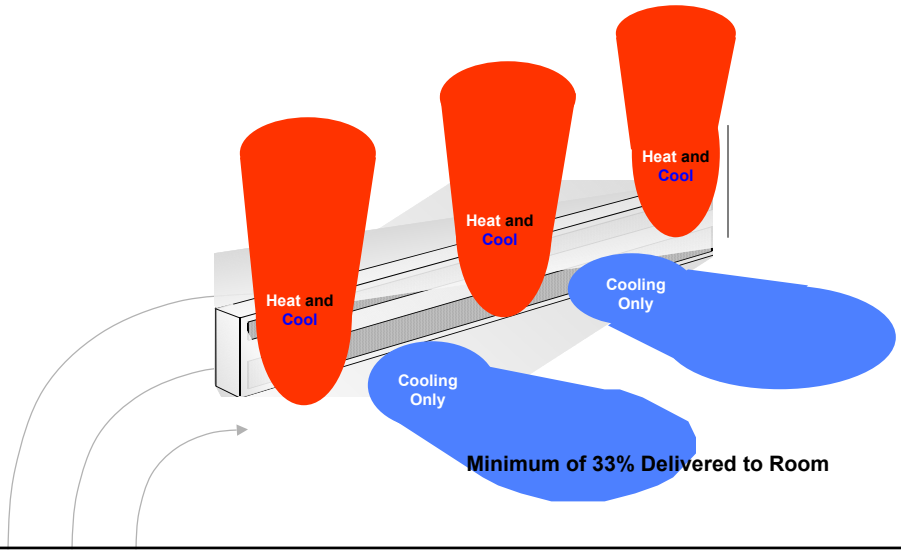
Classroom Heating Operation



Radiant Cooling?

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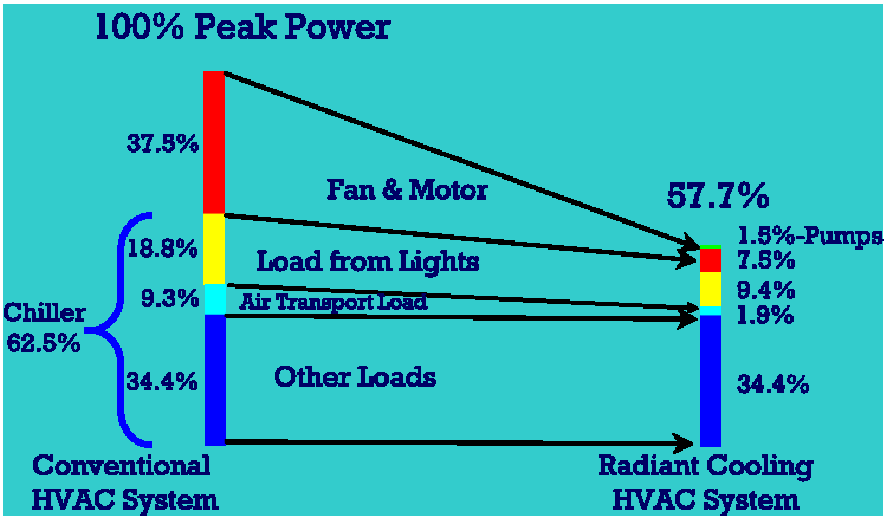

Comfort

100 W = 341.5 BTU

- Human heat-transfer consists of evaporation, convection and radiation
- Chilled ceilings closely model the function of the human body, making it an ideal solution for cooling

- **The heat-transfer with radiation is more comfortable than with evaporation or convection**
- **Radiant Cooling causes no air movement and no drafts**
- **Radiant Cooling makes no noise!**
- **Radiant Cooling offers the highest possible human comfort!**

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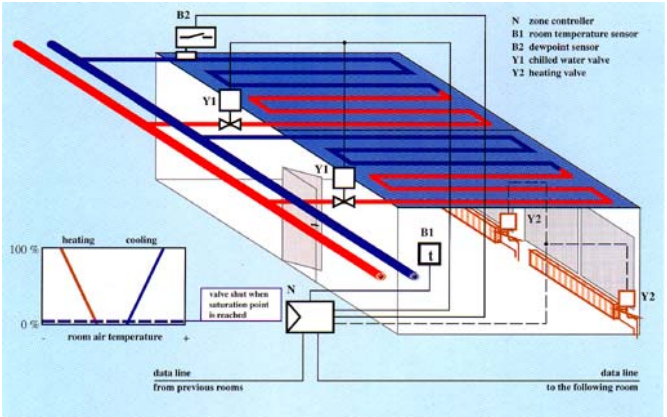
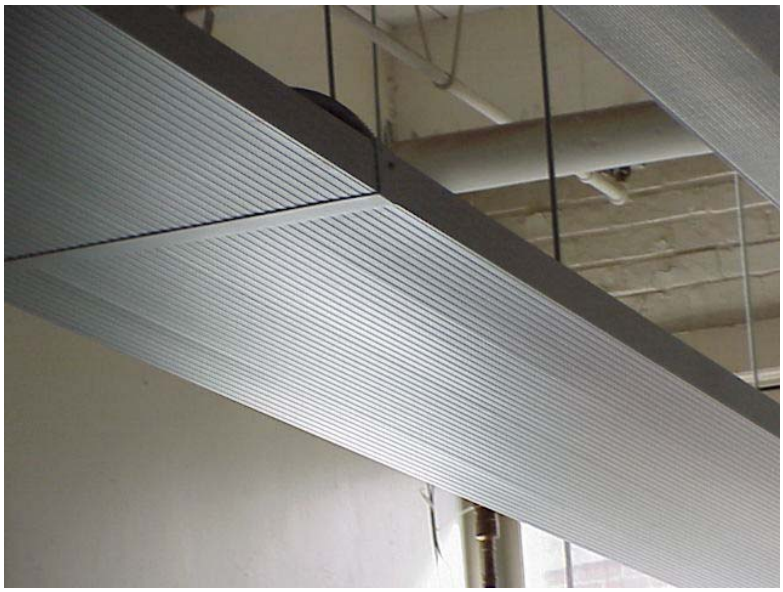
Chilled Ceilings in the System





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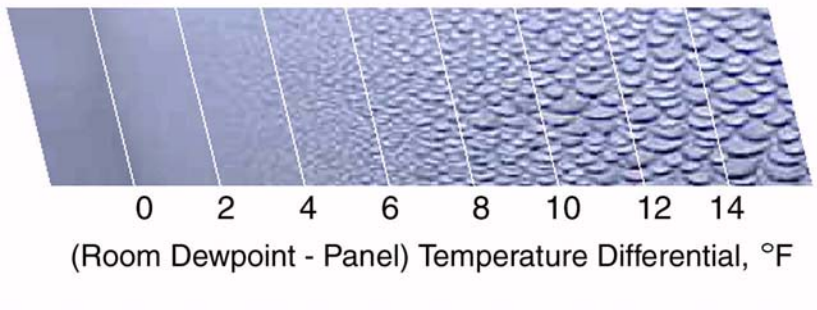
Extreme Condensation, after 8.5 hr. on a chilled panel intentionally held 14°F below the space DPT



Adaptive Control Systems

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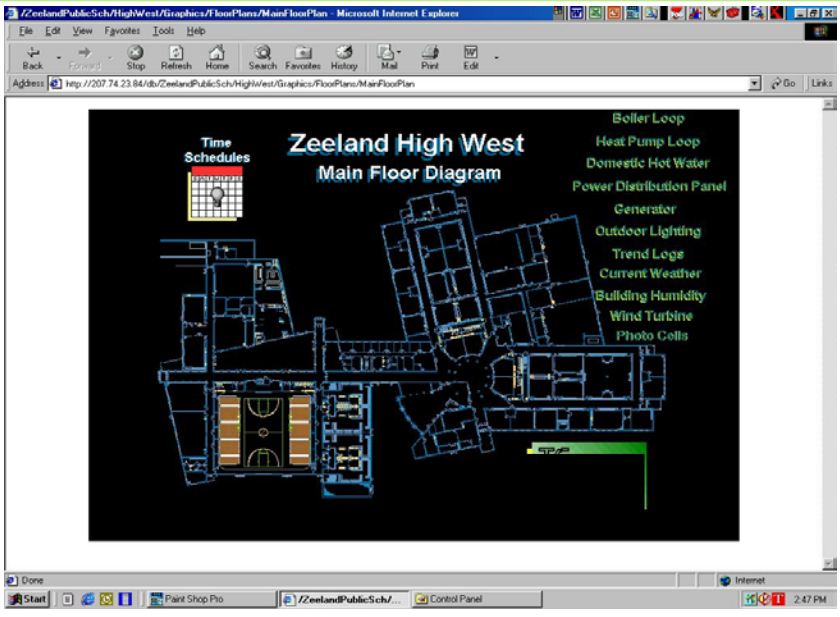
Web Browser Control Access



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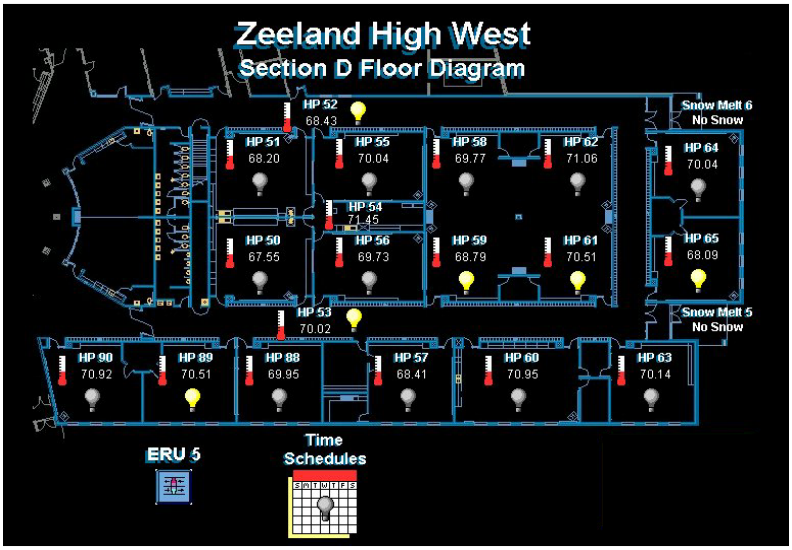

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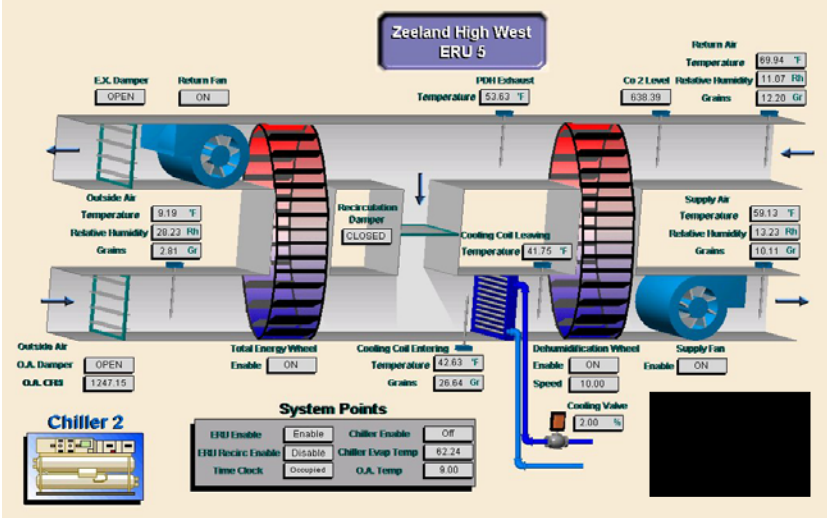

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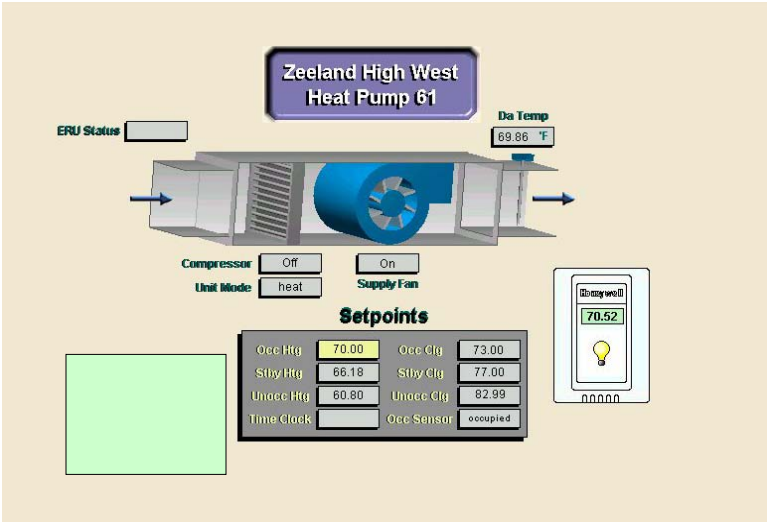

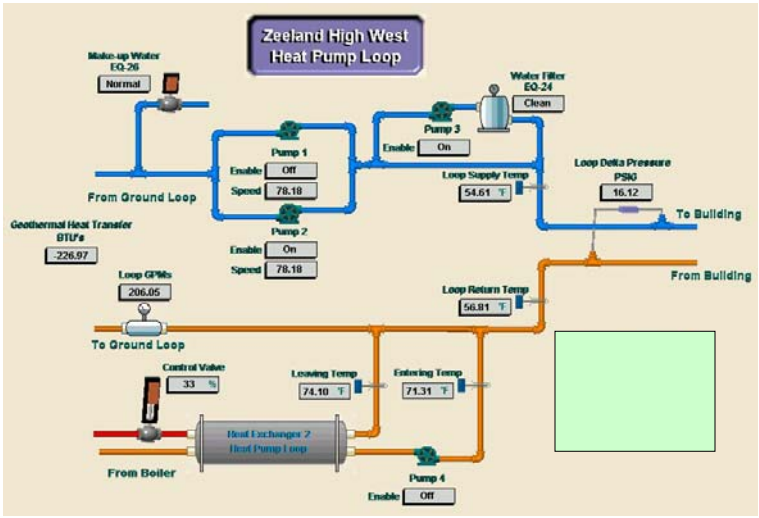

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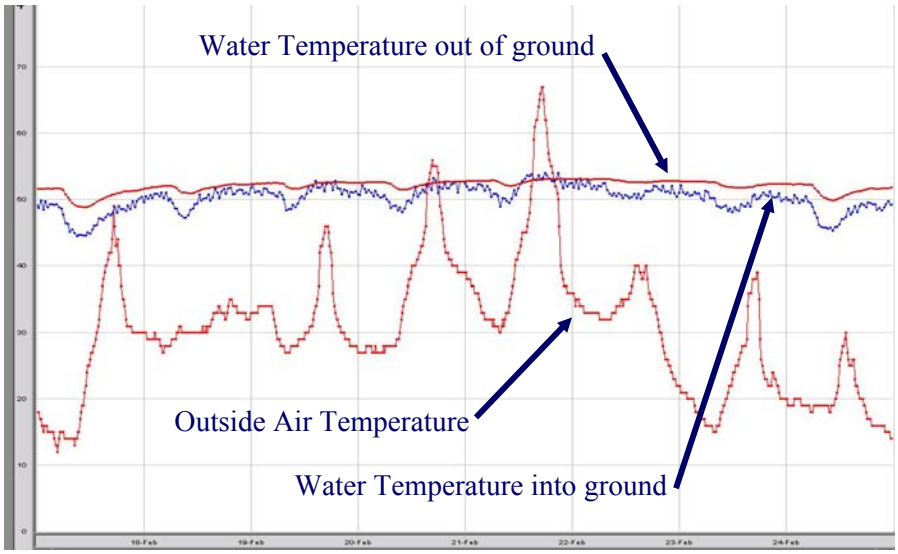

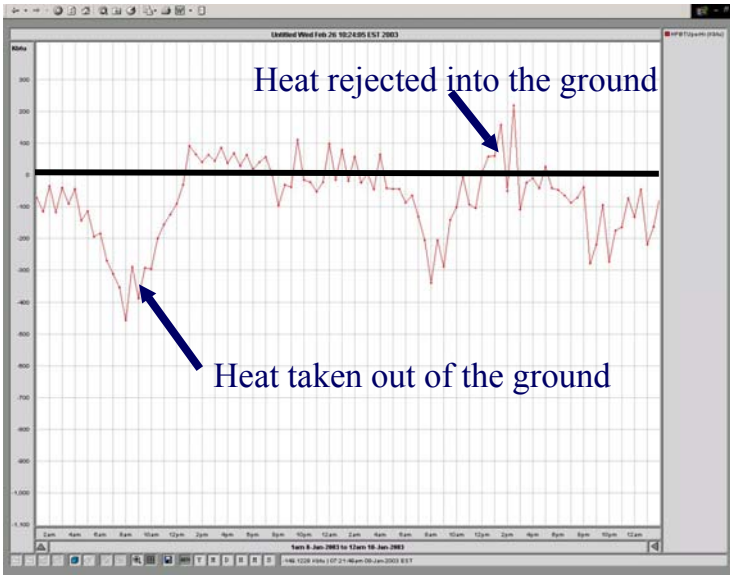

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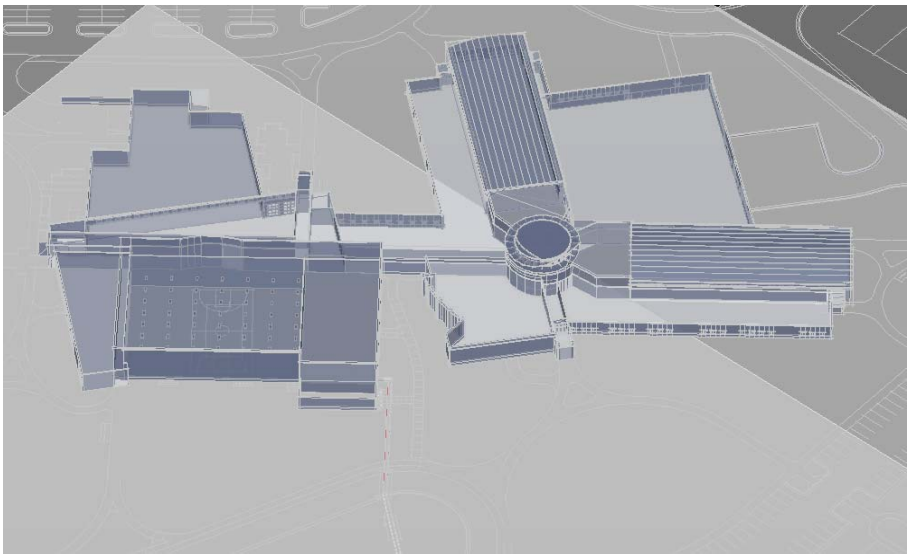
Renewable Energy Systems



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Wind Turbine

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Wind Turbine

10 kW

23’ Diameter Rotor

85’ tall tower

Real-time monitoring system

ZPS Payback – 4 to 6 years

Educational use – 20 to 30 year payback

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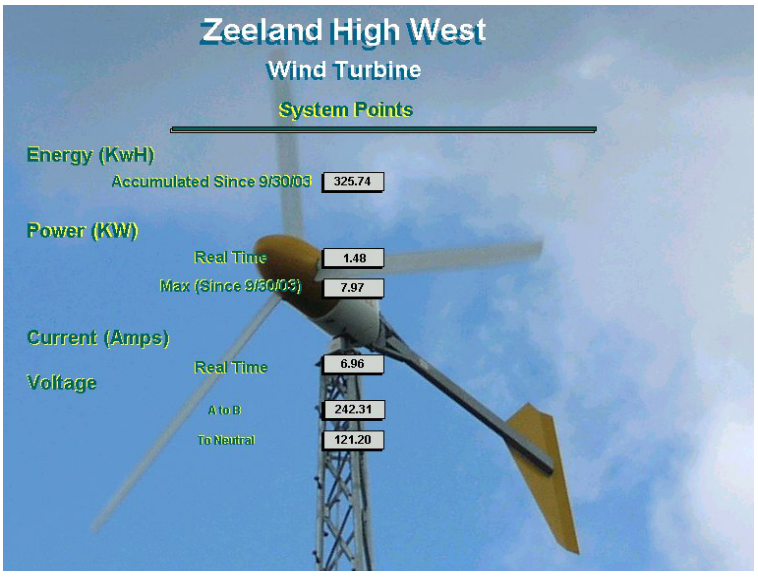
Wind Turbine



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1 kW Photovoltaic Array

Photovoltaic systems convert sunlight directly to electricity with no pollution.

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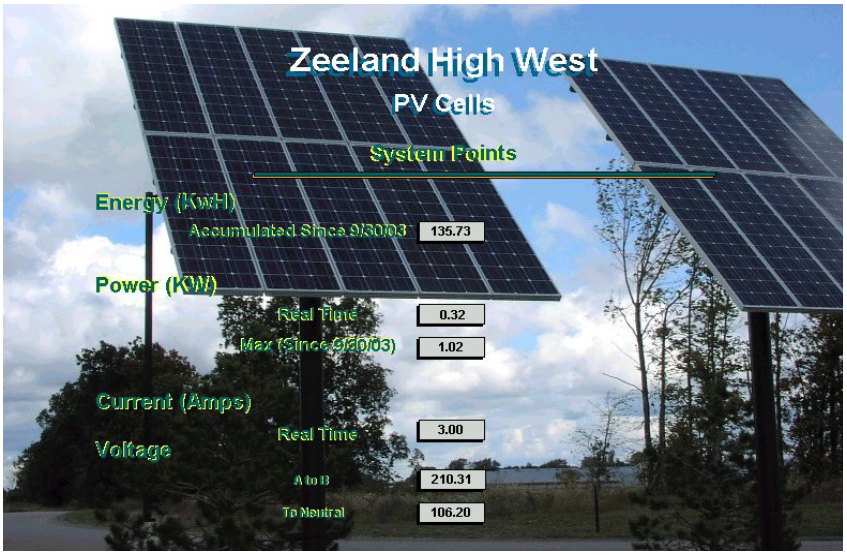
1 kW Photovoltaic Array



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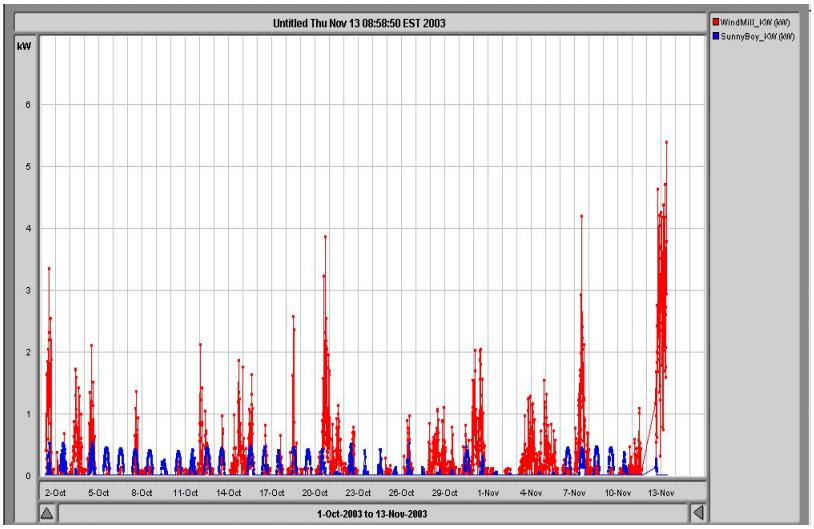
Renewable Energy Systems



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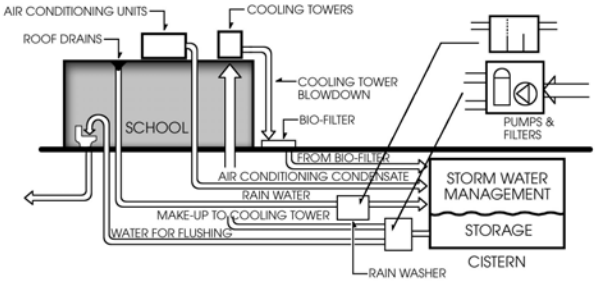
Water Efficiency



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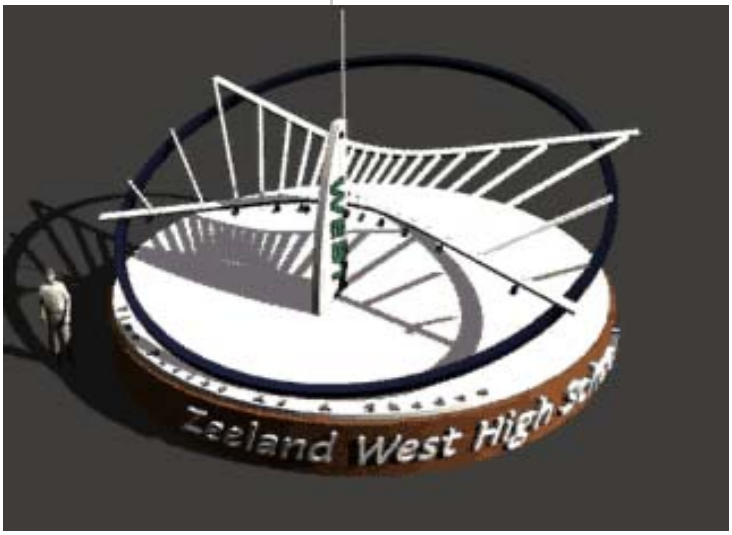
Questions?



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Thank You!

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WINDS OF LEARNING

Turbine installed at high school will serve as energy-saver, teaching tool

ZEELAND

THE HOLLAND SENTINEL
Tuesday, October 21, 2003
Page A3

New school saves big on energy bill

By KORTNI CHRISTIAN
Staff writer

ZEELAND

Mission accomplished.

That was the assessment of David Van Ginhoven, assistant superintendent for business for the Zeeland Public School District, on designing Zeeland West High School to maximize energy savings.

Van Ginhoven presented a report to the school board Monday at its regular meeting stating that the district had saved an estimated $40,000 to $50,000 in energy costs in West's first year of operation. The savings included $30,000 during December, January and Februarv.

formance, must be carried into other facilities within the school district," Van Ginhoven said in a written statement to the board.

Charts show that Zeeland East High School used the most energy of all the district's buildings, while the Early Childhood center used the least. Van Ginhoven said the energy costs at East were due to the fact that the building gets the most use for community and school events.

One of the factors in the savings at West is a GeoExchange system, which includes a buried network of 20 miles of pipe in a

it under a circulated it and cool

the building. The system does not cost any more to put into buildings, and saves on using natural gas to heat the building, Van Ginhoven said.

The new elementary that is being built on Quincy Street will use the same "green" design used in Zeeland West, Van Ginhoven said.

The district spends an estimated $1 million on energy throughout the district, which includes water and sewage, natural gas and electricity on all of its buildings.

Van Ginhoven said there was room for improving the energy savings, which include analyzing and identifying peak times of use within individual buildings. Van Ginhoven said the district was in the process of analyzing the data through computer systems.

'Green' design saves on costs for Zeeland school building